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(54) Centrifuge with flow influencing means.

(57) In the rotor of a centrifugal separator a stack of conical separation discs (4) is arranged concentrically with the rotor axis. The rotor has an inlet for a dispersion and an outlet for liquid having been freed from a substance dispersed therein. In each space between adjacent separation discs (4) the disc surface from which the dispersed substance moves away as a consequence of the centrifugal force during rotor operation has flow influencing member (17), whereas the surface of the other separation disc, situated opposite to said members, is substantially smooth. The relation (L/H) between the distance (L) between adjacent flow influencing members and the distance (H) between the separation discs and the relation (1/H) between the extension (1) of each flow influencing member along the disc surface and the distance (H) between the separation discs are larger than zero but less than 2.

EP 0 320 105 A1

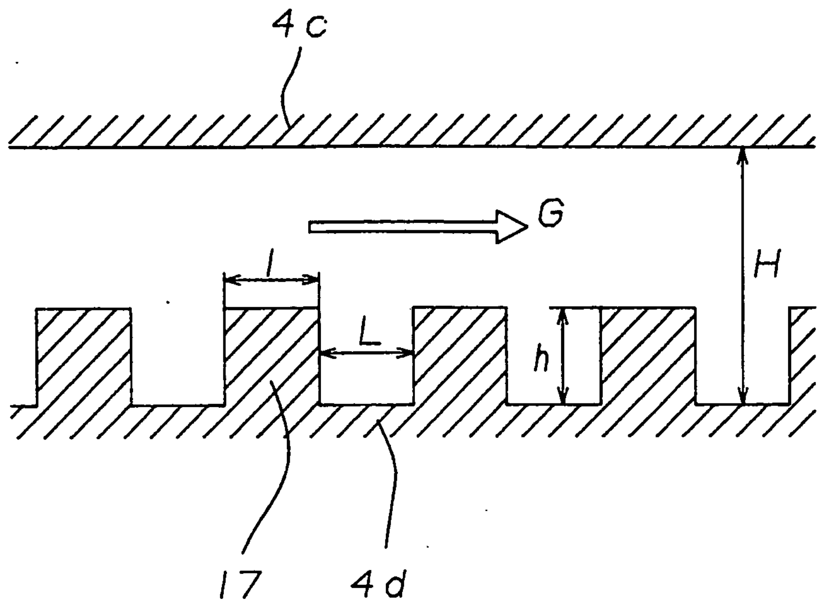

FIG 5

Centrifugal Separator

The present invention relates to a centrifugal separator for the separation of a substance that is dispersed in a liquid, comprising a rotor having a separation chamber and an inlet for a dispersion and an outlet for separated liquid, a stack of conical separation discs separated coaxially with the rotor in the separation chamber, and flow influencing members situated in at least a part of the interspaces between the separation discs, which members in each of said interspaces are arranged in contact with the surface of one of the separation discs, from which the dispersed substance will move away during operation of the rotor as a consequence of centrifugal force action, but at a distance from the surface of the other separation disc towards which the dispersed substance will move during operation of the rotor as a consequence of centrifugal force action, so that a space is formed between the members and said other separation disc, which admits flow of dispersion in the circumferential direction of the rotor past the members, said flow influencing members forming flow ways between themselves extending between radially outer and inner areas of said one separation disc.

A centrifugal separator of this kind described in the Swedish patent specification No. 7503054-4 is equipped with flow influencing members in the form of radially extending ribs. It is stated that these ribs give the result that in each interspace between the separation discs "the flow is distributed in a manner such that the largest part (80-90%) of the suspension flows in the interspaces between the ribs 15", whereas in the space between the ribs and the separation disc, towards which suspended particles move during the rotor operation as a consequence of the centrifugal force, "there are formed stagnation zones, where the suspension flows at a small speed". As a consequence thereof, it is further stated, a decrease of the speed gradient is obtained near the separation disc surface towards which suspended particles are moved by the centrifugal force, so that a more effective separation of these particles may be obtained. The efficiency of a centrifugal separator, it is said, may thereby be increased 2-5 times in comparison with that of a conventional centrifugal separator.

Neither the details about the shape and location of the ribs give in said patent specification nor the explanation given in the patent specification as to the function of the ribs can be used to enable in practice an improvement of the efficiency of a centrifugal separator in accordance with what is alleged. The reason therefor will be evident from the following.

The object of the present invention is to provide a centrifugal separator of the initially defined kind, which is designed such that a substantial improvement of the separation efficiency can be obtained by means of flow influencing members between the separation discs.

According to the invention this is possible if the flow influencing members - in order to prevent to a substantial degree the formation of so called Ekman layers along the surface of said one separation disc -are formed such that the relation between the distance between adjacent flow influencing members, seen in the circumferential direction of the rotor, and the distance between the separation disc surfaces and the relation between the extension of each member in the circumferential direction of the rotor and the distance between the separation disc surfaces are both larger than zero but less than 2, preferably between 0, 2 and 1, 0 and if the surface of said other separation disc, opposite to the flow influencing members, is formed in a manner known per se for the obtainment of Ekman layers along the same during operation of the rotor.

By this invention it is possible to prevent formation of so called Ekman layers at the separation disc surfaces having flow influencing members and, instead, to establish close to these separation disc surfaces a flow providing the same effect as a very thick hypothetical Ekman layer. In other words, the effect is obtained that the radial flow of dispersion of each interspace is distributed such that the main part of the radial flow comes up close to the flow influencing members and only a small part comes up near the separation disc surface towards and along which substance separation from the dispersion should move. By the particular shape of the flow influencing members turbulence of the dispersion in the interspace between the separation discs is avoided which turbulence would counteract an effective separation of the dispersed substance. Such an undesired turbulence between the separation discs may occur with an arrangement of the flow influencing members according to the previously mentioned Swedish patent specification. Furthermore, in this known arrangement so called Ekman layers will be formed between the described ribs as well as on the upper sides of the same, for which reason the radial flow of dispersion will be substantially of the same magnitude along both of the two separation discs limiting the interspace in question.

In a preferred embodiment of the invention the flow influencing members have the form of evenly distributed protuberances from said one separation

disc surface in each plate interspace, each protuberance having substantially the same extension in all directions along the disc surface. By such a rough and a homogeneous structure of the disc surface in question substantially uniform flow conditions can be obtained along the whole disc surface.

The invention is described in the following with reference to the accompanying drawing, in which:-

Fig. 1 shows a centrifugal separator having conical separation discs, to which the invention is applicable,

Fig. 2 shows a conical separation disc seen from above,

Fig. 3 shows a radial section through two smooth separation discs and an interspace therebetween,

Fig. 4 shows a part of a separation disc provided with flow influencing members according to the invention, and

Fig. 5 illustrates an interspace similar to that in Fig. 3 but where one of the separation discs has flow influencing members according to the invention

Fig. 1 shows a centrifuge rotor supported by a vertical drive shaft 2. Within the rotor a separation chamber 3 is formed in which - coaxially with the rotor - a stack of frusto-conical separation discs 4 is arranged. The rotor 1 has a central inlet chamber 5 for a dispersion of components to be separated in the separation chamber 3, and a central outlet chamber 6 for a separated relatively light liquid. A stationary inlet tube 7 extends into the inlet chamber 5, and a stationary outlet member 8 extends into the outlet chamber 6. At its periphery the rotor has an intermittently openable outlet 9 for a separated relatively heavy component, e.g. sludge which before separation constitutes the dispersed phase of the supplied dispersion. The inlet chamber 5 communicates with the separation chamber 3 through several radial channels 10 evenly distributed around the rotor axis. Through an overflow outlet 11 the separation chamber 3 communicates with the outlet chamber 6.

Fig. 2 shows a separation disc 4 which on its upper side is provided with a number of radially extending ribs 12 intended to serve as spacing means between this separation disc and an adjacent separation disc in a centrifuge rotor according to fig. 1. The intended direction of rotation is shown by means of an arrow R.

During operation of a centrifuge rotor according to Fig. 1 a.dispersion supplied to the inlet chamber 5 is caused to rotate at the same speed as the rotor during its passage through the radial channels 10. The angular speed which the dispersion has reached in the area of the outer edges of the separation discs 4 will increase further, when the dispersion is forced to flow back towards the rotor axis between the separation discs. This increase of the angular speed, depending on the fact that each part of the rotating dispersion is striving at maintaining its momentum, cannot be prevented by spacing members between the separation discs, such as ribs of the kind shown in Fig. 2.

As a consequence of the above a flow of dispersion will take place in each interspace between adjacent separation discs, that is directed substantially around the rotor axis. This flow having a speed in circumferential direction of the rotor larger than that of the separation discs themselves is named in the following geostrophic flow. A flow line for part of this geostrophic flow is shown in Fig. 2 and designated 13. As shown, the ribs 12 form obstacles to a substantially circular geostrophic flow. Such a circular flow can be obtained, however, if the ribs are substituted by spot-like protuberances as are sometimes issued.

The geostrophic flow of the dispersion moving around the rotor axis, i.e. substantially in the circumferential direction of the rotor, the formation of which, however, thus depends on the fact that the dispersion is forced to moving towards the rotor centre through the disc interspaces, experiences friction at the surfaces of the separation discs. As a consequence of this friction, a flow of liquid arises in a very thin layer closest to each disc surface, which flow has a substantially larger radially inwards directed component than the geostrophic flow, at least where the latter goes in the circumferential direction of the rotor. The thin layer usually is named Ekman layer. In the case just described, when the geostrophic flow moves faster than the separation discs, the liquid in the Ekman layers flows along the disc surfaces radially inwards. If the geostrophic flow had been moving slower than the separation discs, which would have happened if the dispersion had been forced to move radially outwards through the disc interspaces, the liquid in the Ekman layers would instead have been flowing radially outwards.

Fig. 3 illustrates how the radial flow may be distributed in different layers of an interspace between two conventional smooth separation discs 4a and 4b. The rotor axis is illustrated by a line 2a. The radial flow velocity is zero at the surfaces of the separation discs and substantially zero also in a large area 14 midway between the separation discs. A substantial radial flow exists only in two layers 15 and 16 close to the separation discs. These layers are the two above said so called Ekman layers. Substantially all dispersion to flow through the space between the separation discs 4a and 4b from their outer edges to their inner edges is thus forced to flow radially inwards in the layers

15 and 16. The thickness of each Ekman layer for most practical operation conditions is in the order of 1/10 of the distance between two adjacent separation discs.

A substance dispersed in the dispersion, e.g. small solids heavier than the carrying liquid will by the centrifugal force in the interspace between the separation discs strive at moving radially outwards toward the separation disc 4a and along it towards its outer edge. Such a flow of solids towards and along the separation disc 4a will be made difficult by the radially directed dispersion flow in the layer 15. Therefore, it would be desirable to accomplish, if possible, a different distribution of the radially inwards directed flow of the dispersion, so that it would be smaller in the area 15 and larger in the area 16. Such a desired flow distribution is shown by a dotted line in Fig. 3.

According to the invention this is possible to accomplish by providing the separation discs 4 on their upper sides with flow influencing members 17 shaped in a particular way, such as can be seen from Fig. 4 and Fig. 5. The flow influencing members 17 have to be so formed that they give the upper side of each separation disc a rough surface structure, which prevents the formation of an Ekman layer thereon. Furthermore, they have to be so formed that even if they create a substantially larger friction resistance for the geostrophic flow along said upper side than a smooth surface would do, they should still not cause turbulence in a large part of the disc interspace. This would make it difficult or impossible for the intended separation of the dispersed substance to take place. According to the invention, the flow influencing members, for the achievement of the desired effect, have to be so formed that the relation between the distance adjacent members, seen in the circumferential direction of the rotor, and the distance between the separation discs, and the relation between the extent of each member in the circumferential direction of the rotor and the distance between the separation discs are both less than 2.

The just used expression, "in the circumferential direction of the rotor" should be understood as "in the direction of the geostrophic flow". It is not certain that flow influencing members are required across the whole upper side of each separation disc. Particularly if ribs or other flow obstacles are present in the plate interspaces, it is possible that flow influencing members may be omitted over parts of said upper side.

Fig. 5 shows a section through parts of two adjacent separation discs 4c and 4d and the interspace therebetween. The upper side of the lower disc 4d has a number of flow influencing members 17 (see also Fig. 4) each with an extension $\underline{l}$ along the plate surface and a height $\underline{h}$ above the same. The distance between two adjacent flow influencing members is designated $\underline{L}$ and the distance between the separation discs is designated $\underline{H}$. The direction of the geostrophic flow in the disc interspace is shown by an arrow $\underline{G}$.

Generally accepted theories about so called Ekman layers show that formation of an Ekman layer requires a geostrophic flow a predetermined minimum distance along a surface. This distance is relatively short. By the above defined relation between the distance between the separation discs and the mutual distance between the flow influencing members and their extension along the disc surface in question, respectively, i.e. that l/H and L/H should be less than 2, there will be formed no Ekman layer on the upper side of the separation disc 4d in connection with practically used parameters such as flow, viscosity, rotational speed, etc. for centrifugal separators of the kind here concerned. Furthermore, by the defined relation, turbulence in the disc interspace above the flow influencing members 17 is avoided.

The height $\underline{h}$ of each flow influencing member 17 may vary within wide limits according to the invention. Preferably, however, the relation h/H, i.e. the relation between the height of each member and the distance between the separation discs, should be in the range 0,2 - 0,5.

In a centrifugal separator of the kind for which the invention is intended, the disc plate thickness usually is in the order of 0,5 - 1,0 mm, and the distance (H) between adjacent discs is in the order of 0,5 - 1,5 mm. This means that flow influencing members formed according to the invention may have a height of for instance 0,1 - 0,7 mm and an extension along the separation disc surface and the geostrophic flow of for instance 0,2 - 3,0 mm.

The invention has been described above applied to a case in which a dispersion contains a dispersed substance heavier than the continuous phase of the dispersion. However, the invention can also be used in connection with separation of a dispersed substance which is lighter than the continuous phase of the dispersion, e.g. separation of cream from milk.

In this case the flow influencing members should be situated on the underneath side of the conical separation discs, i.e. on the disc side from which the dispersed substance moves away owing to the centrifugal force during operation of the rotor.

As already mentioned above the upper or lower sides of the separation discs need not be covered entirely by flow influencing members. Depending upon the shape of necessary spacing means between the separation discs varying direction s of the geostrophic flow may come up. Flow influencing members are most important in that part of a

disc interspace in which the strongest counter-flow can be expected between the separated dispersed substance and an Ekman layer formed as a consequence of the geostrophic flow.

Only one form of the flow influencing members has been described above. Any other form thereof is possible within the scope of the subsequent claims giving parts of the separation discs a rough surface structure. A rough surface structure may be difficult or expensive to accomplish on separation discs made of metal. Therefore, the invention may prove to be applicable in practice, in particular when the separation discs are made of plastic, with the flow influencing members being made in one piece with the separation discs.

Claims

1. Centrifugal separator for the separation of a substance dispersed in a liquid, comprising a rotor (1) having a separation chamber (3) an inlet for a dispersion and an outlet for separated liquid, a stack of conical separation discs (4) arranged coaxially with the rotor in the separation chamber 93) and flow influencing members (17) situated in at least part of the interspaces between the separation discs (4), which members in each of said interspaced are arranged continuous with the surface of the one of the separation discs, from which the dispersed substance moves away during operation of the rotor as a consequence of the centrifugal force action, but at a distance from the other separation disc towards which the dispersed substance moves during operation of the rotor as a consequence of the centrifugal force action, so that a space is formed between the members and said other separation disc admitting flow of dispersion in the circumferential direction of the rotor past the members, said flow influencing member (17) forming flow ways between themselves extending between radially outer and inner areas of said one separation disc, characterised in that

- the flow influencing members (17) are so formed that the relation (L/H) between the distance (L) between adjacent flow influencing members, seen in the circumferential direction of the rotor, and the distance (H) between the surfaces of the separation discs and the relation (1/H) between the extension (1) of each flow influencing member in the circumferential direction of the rotor and the distance (H) between the surfaces of the separation discs are both larger than zero but less than 2, and
- the surface of said other separation disc, opposite to the flow influencing members (17), is formed in a manner known per se for establishing an Ekman layer along the same during operation of the rotor.

2. Centrifugal separator according to claim 1, characterised in that the flow influencing members (17) are formed and placed such that they give said one separation disc a substantially homogeneous surface structure at least over a part of the surface of one side of the disc.

3. Centrifugal separator according to claim 1 or 2, characterised in that all of the said flow influencing member (17) have the same shape.

4. Centrifugal separator according to claim 3, characterised in that each flow influencing member (17) has substantially the same extension in all directions along the surface of said one separation disc.

5. Centrifugal separator according to any of the preceding claims characterised in that the relation (h/H) between the height (h) of each flow influencing member above the surface of said one separation disc and the distance (H) between the surfaces of the separation discs is in the range 0,2-0,5.

6. Centrifugal separator according to any of the preceding claims, characterised in that the relation (L/H) between the distance (L) between adjacent flow influencing members, seen in the circumferential direction of the rotor, and the distance (H) between the surfaces of the separation discs and the relation (1/H) between the extension (1) of each flow influencing member in the circumferential direction of the rotor and the distance (H) between the surfaces of the separation discs are larger than 0,2 but less than 1,0.

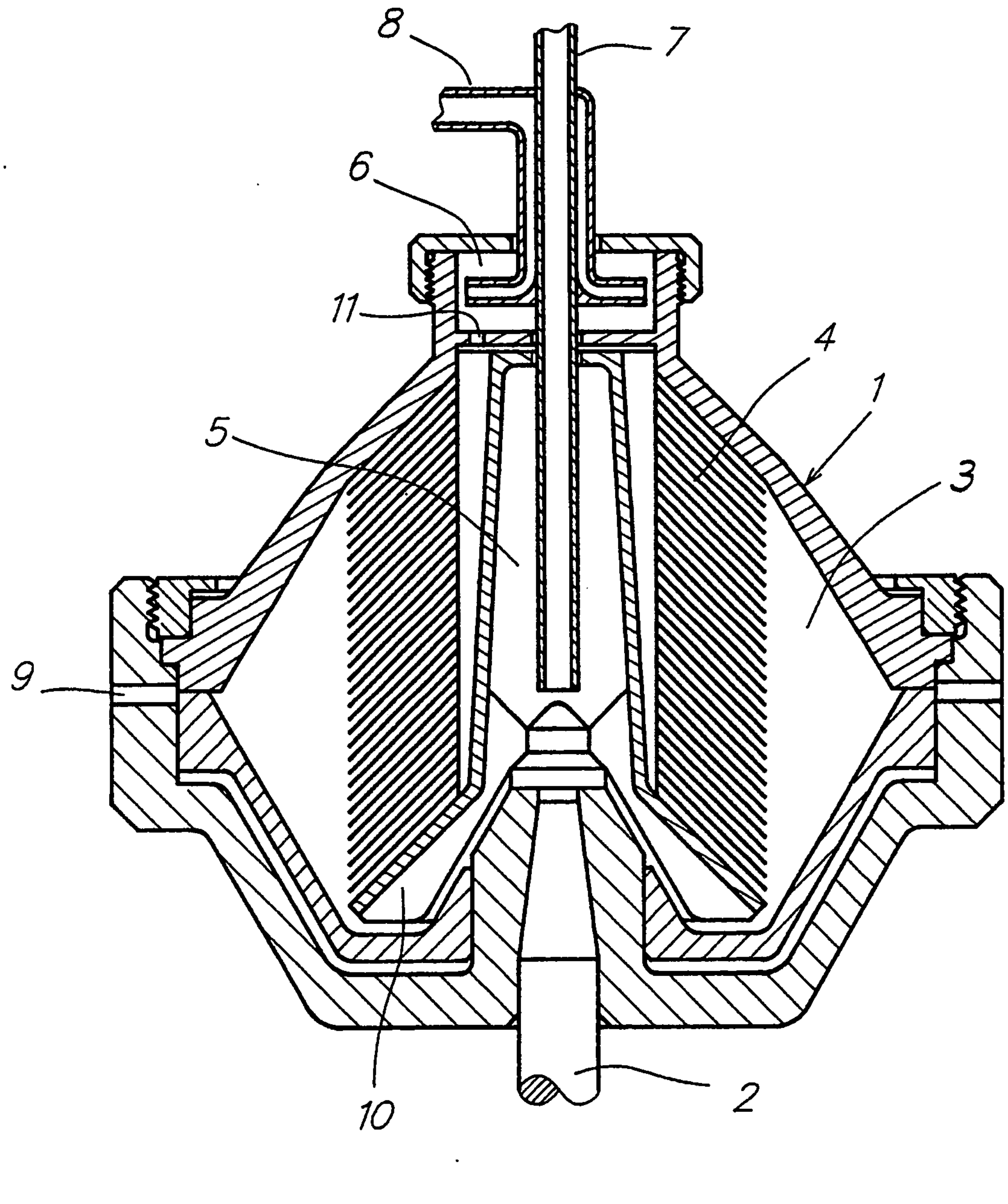

FIG 1

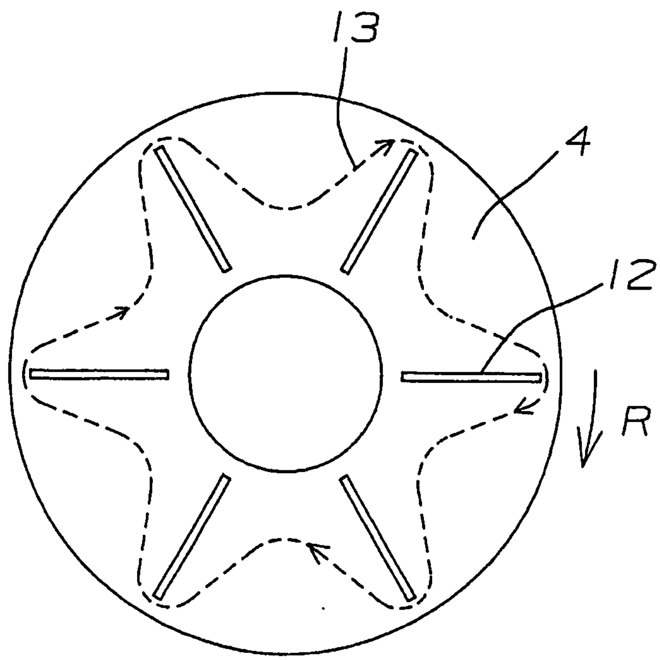

FIG 2

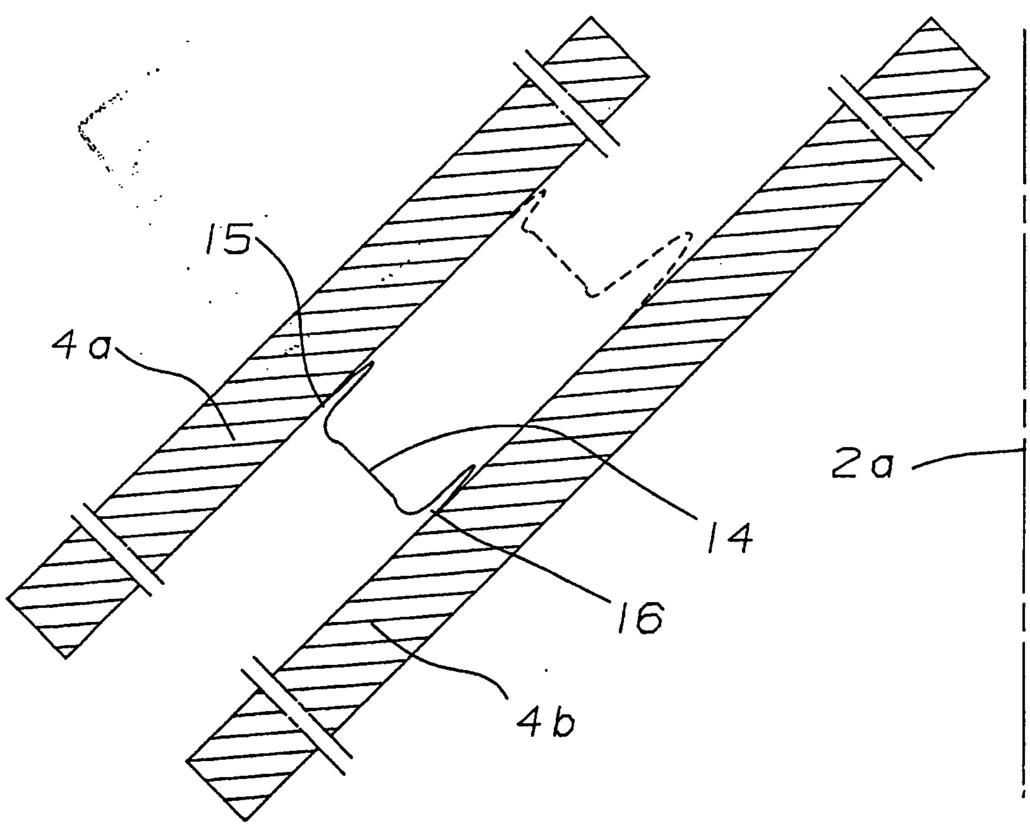

FIG 3

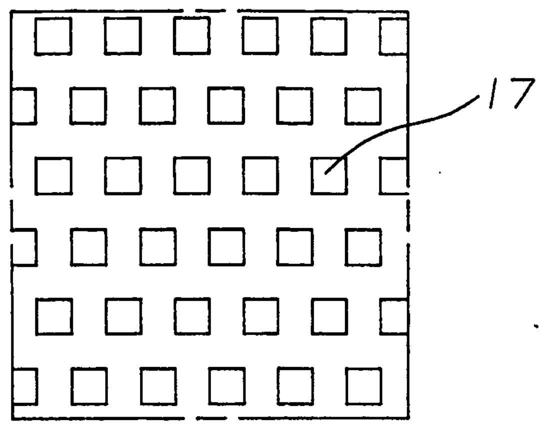

FIG 4

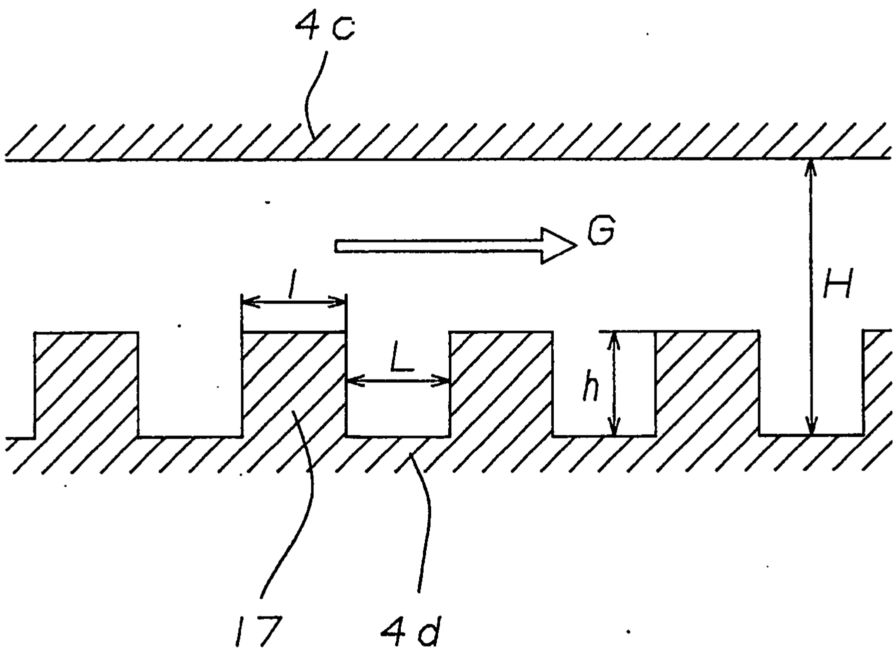

FIG 5

European Patent Office

EUROPEAN SEARCH REPORT

Application number
EP.88310245.1

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
A	SE-B-396 022 (J.F. IFVIN ET AL) ---	1	B 04 B 1/08, 7/14
A	Derwent's abstract No 87573 E/41, SU 889 104 ---	1	
A	US-A-4 631 049 (K.H. ZETTIER) -----	1	
			TECHNICAL FIELDS SEARCHED (Int. Cl.4)
			B 04 B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
STOCKHOLM	24-02-1989	FRANSSON Å

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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